

# PBO H<sub>2</sub>O

## Water Cycle Studies Using The Plate Boundary Observatory

<http://xenon.colorado.edu/portal>

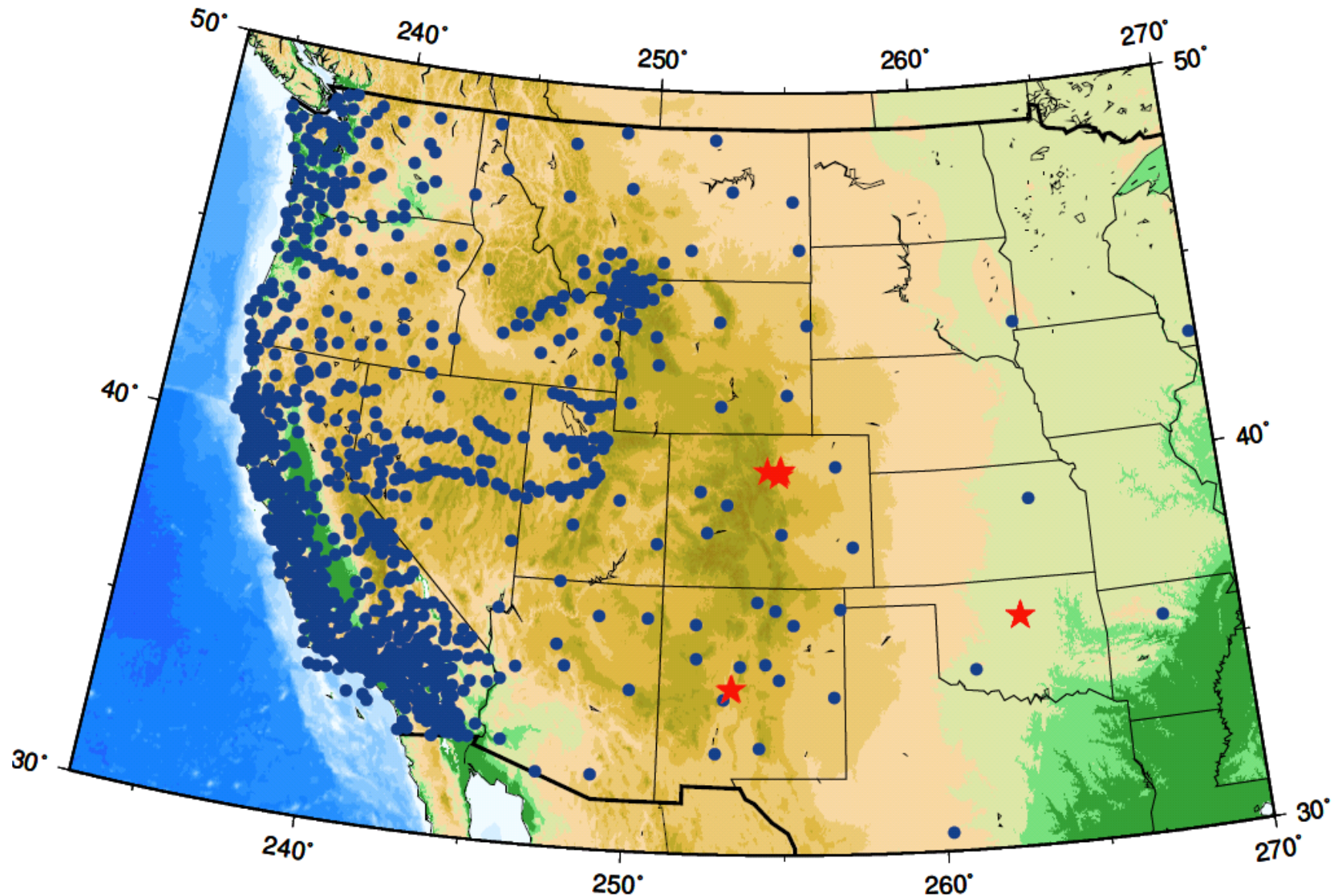


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Goal: Use **GPS reflections** measured by PBO network to estimate terrestrial hydrologic variables



# Using GPS to estimate surface soil moisture

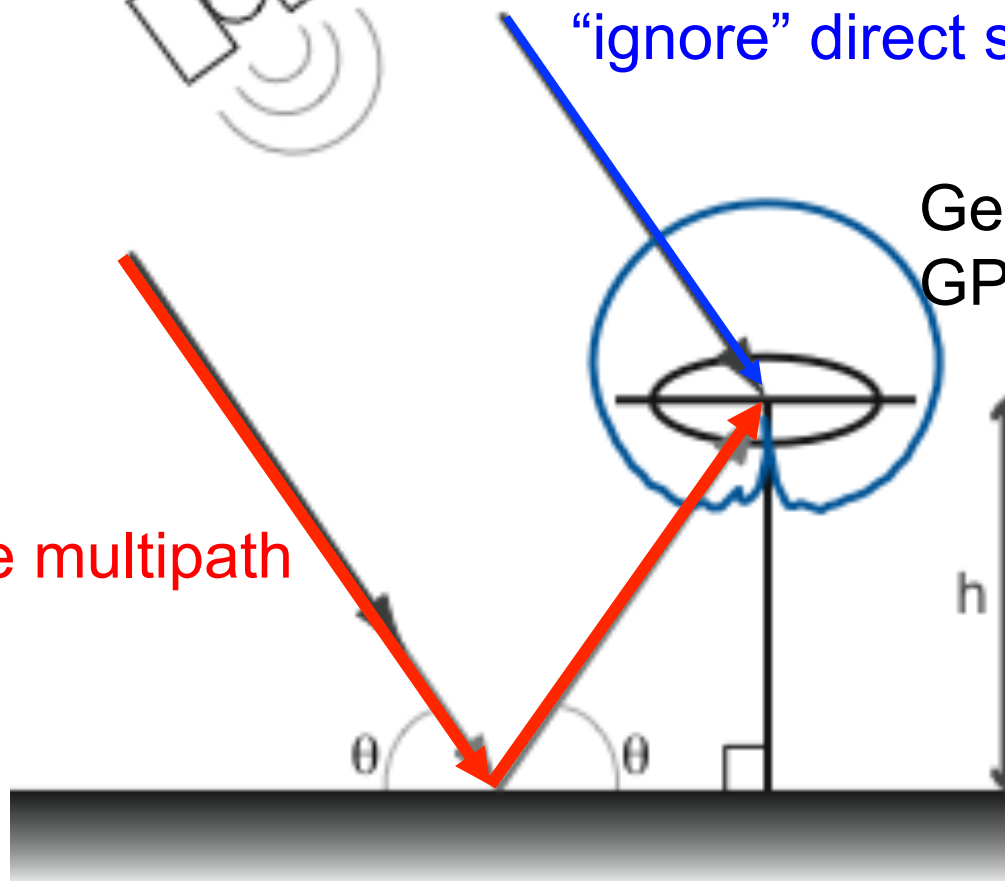
GPS satellite transmitting  
L-band signals



“ignore” direct signal

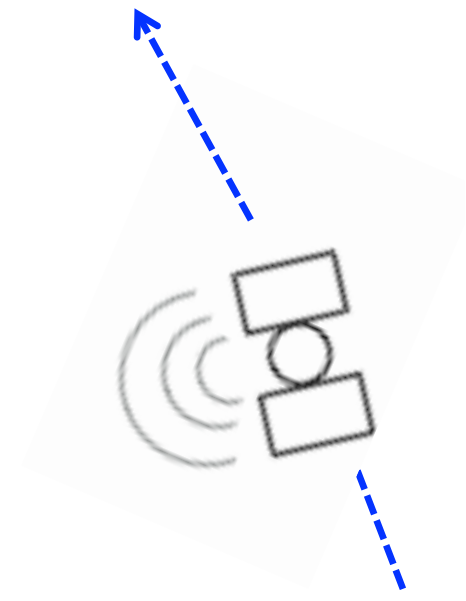
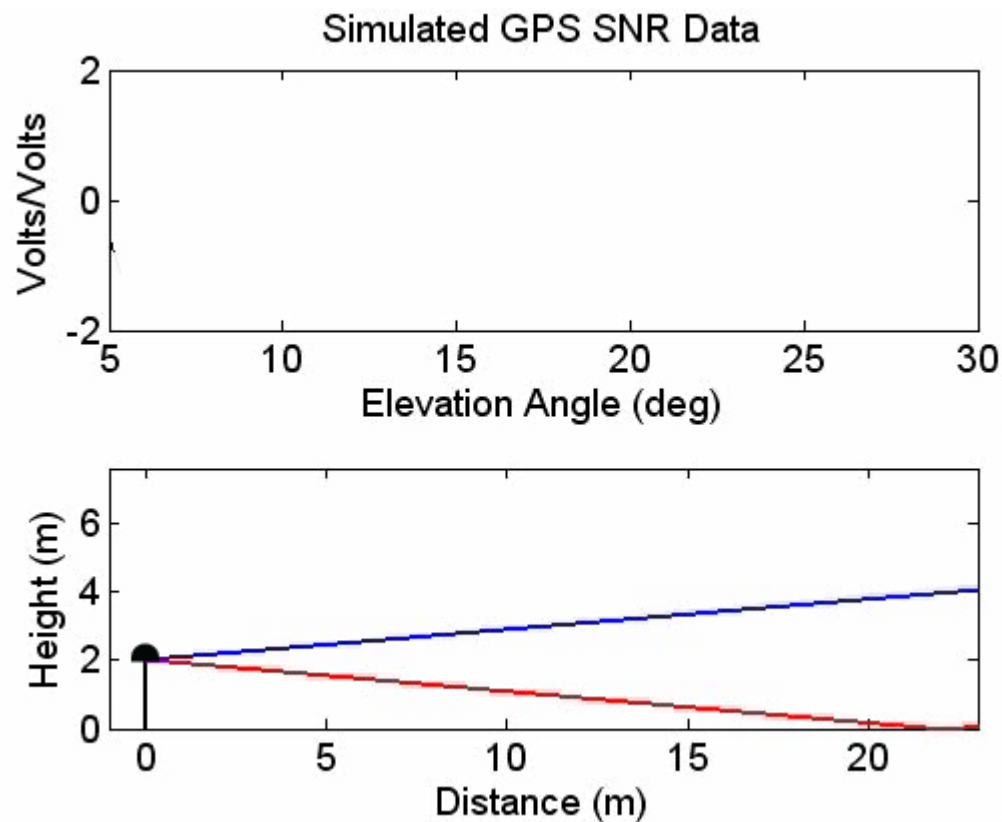
Geodetic-quality  
GPS antenna/receiver

Focus on the multipath

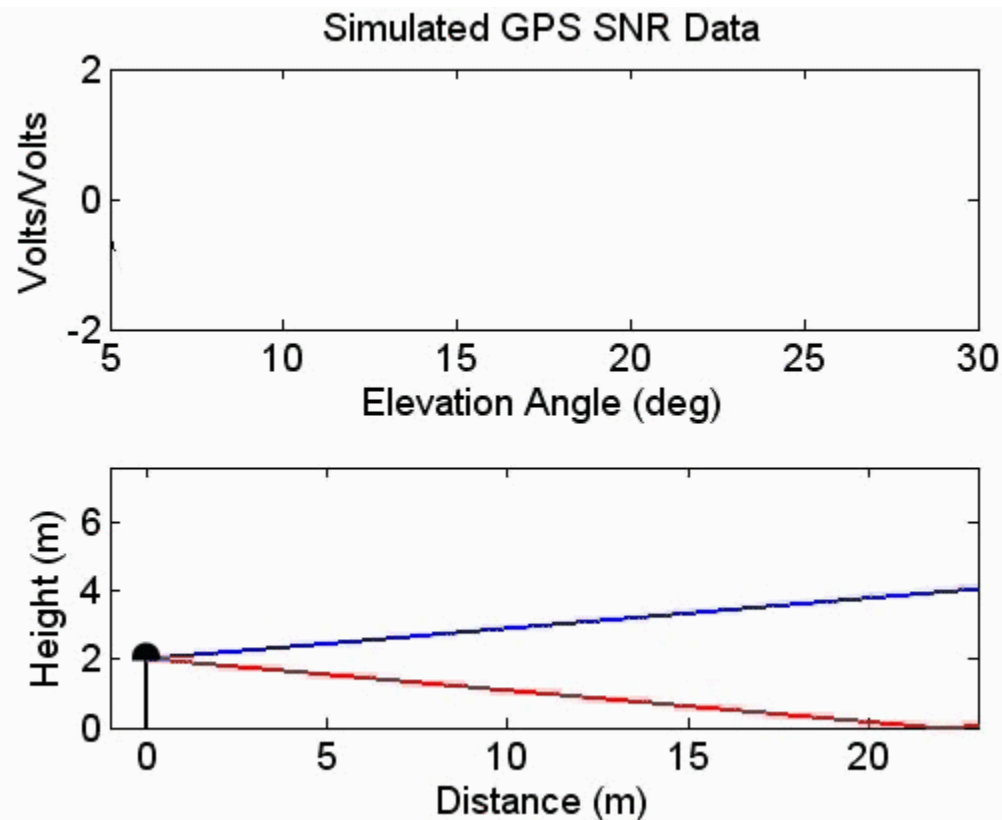




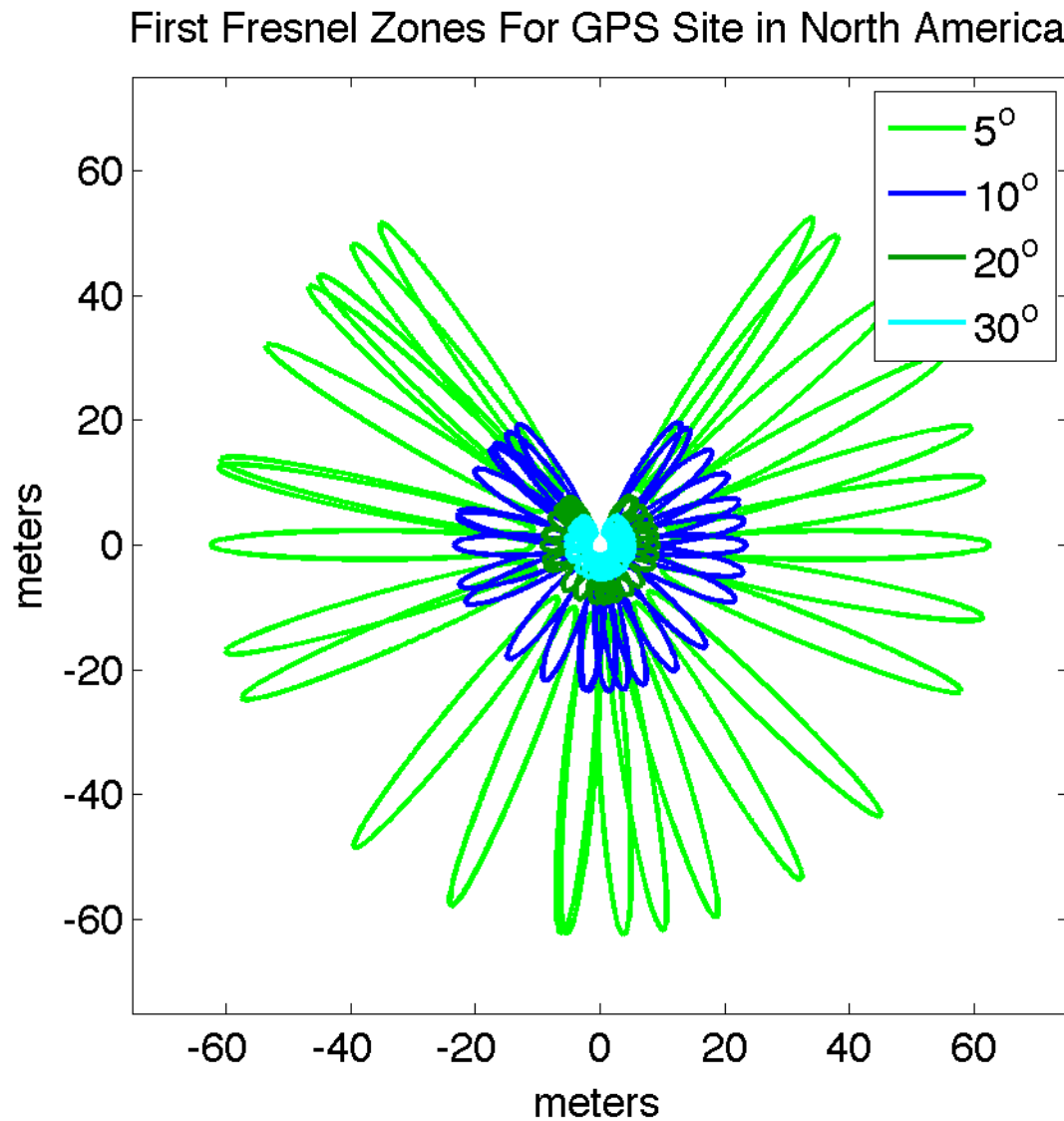
Each rising or setting GPS satellite samples a ground track  $\rightarrow$  Interference pattern in SNR data



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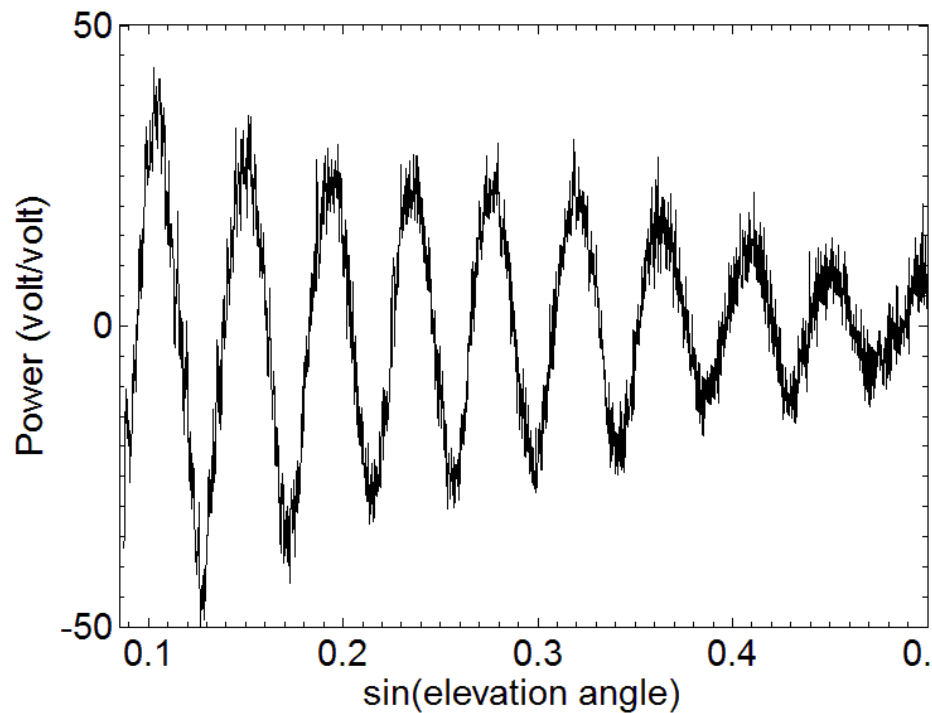


Result: 20 observations per day (maximum)  
Sampling area:  $\sim 1000 \text{ m}^2$

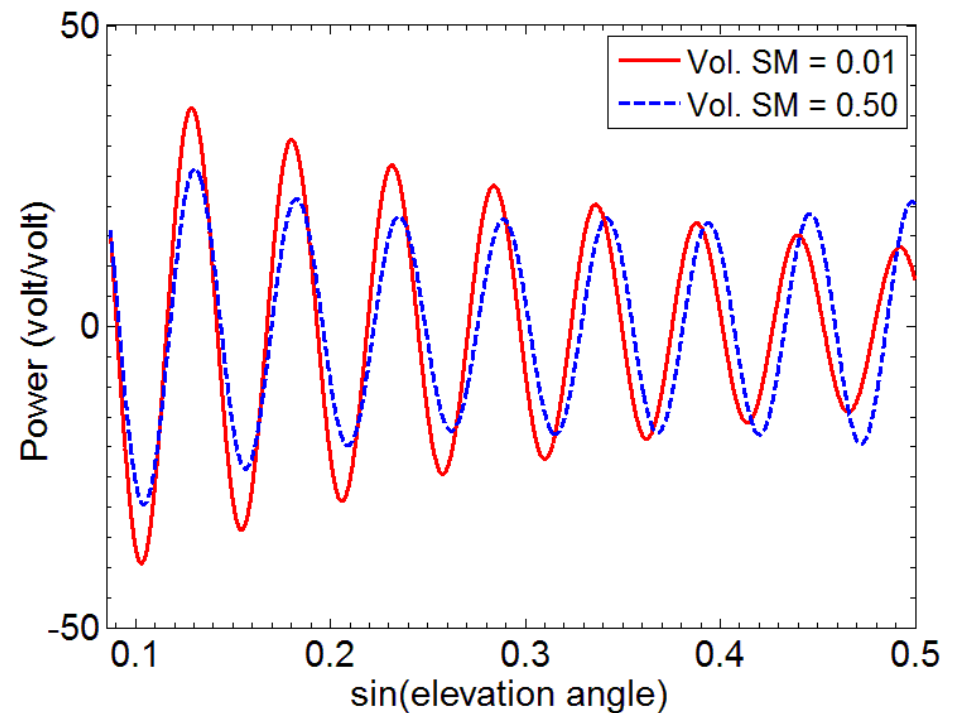


# Use interference pattern to estimate soil moisture

Observed



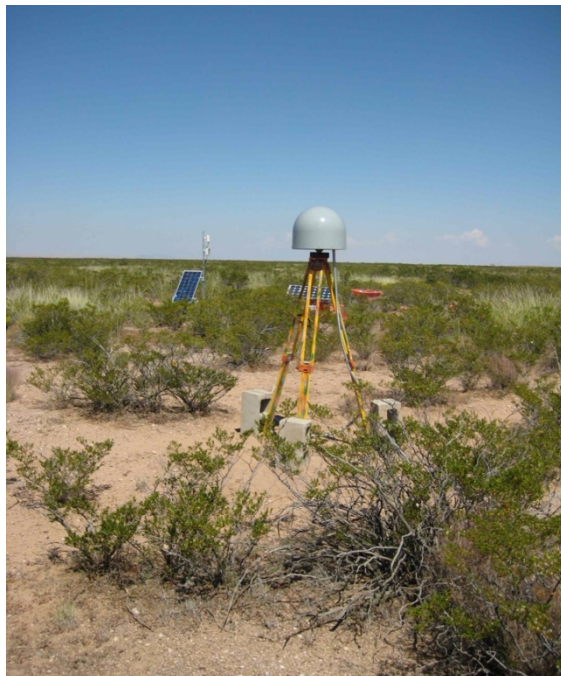
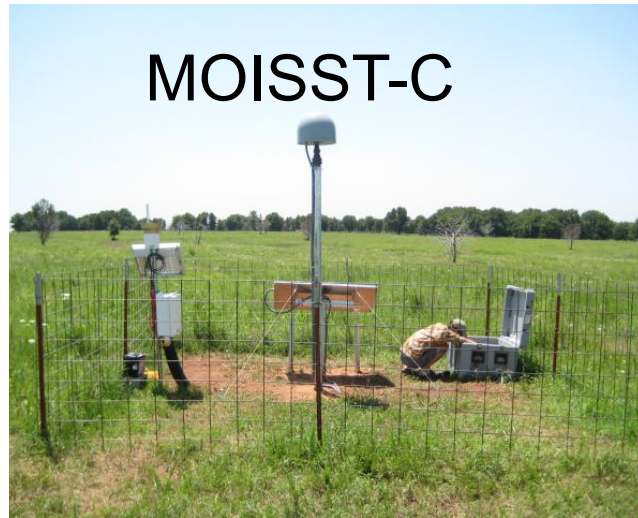
Modeled



Phase varies linearly with surface soil moisture



# Field data: 10 test sites with identical GPS and hydrology infrastructure

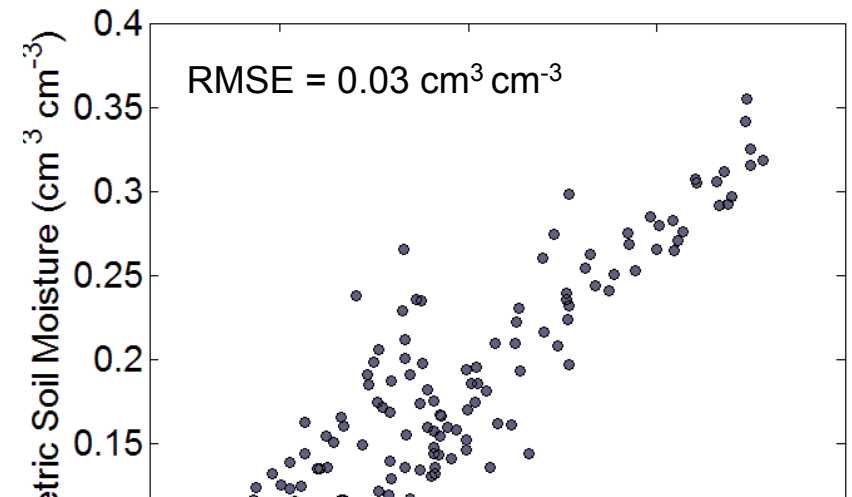




# Validation:

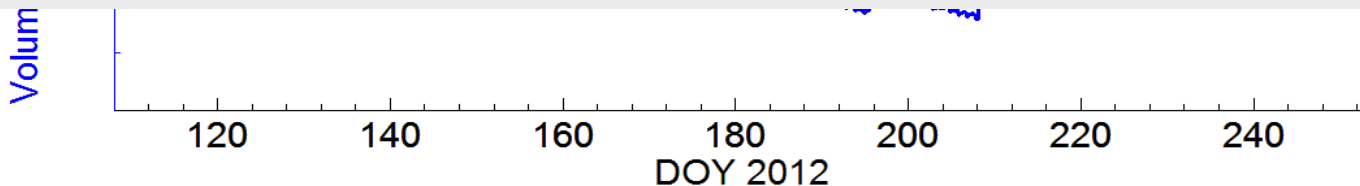
*In situ* probes

Theta probe surveys



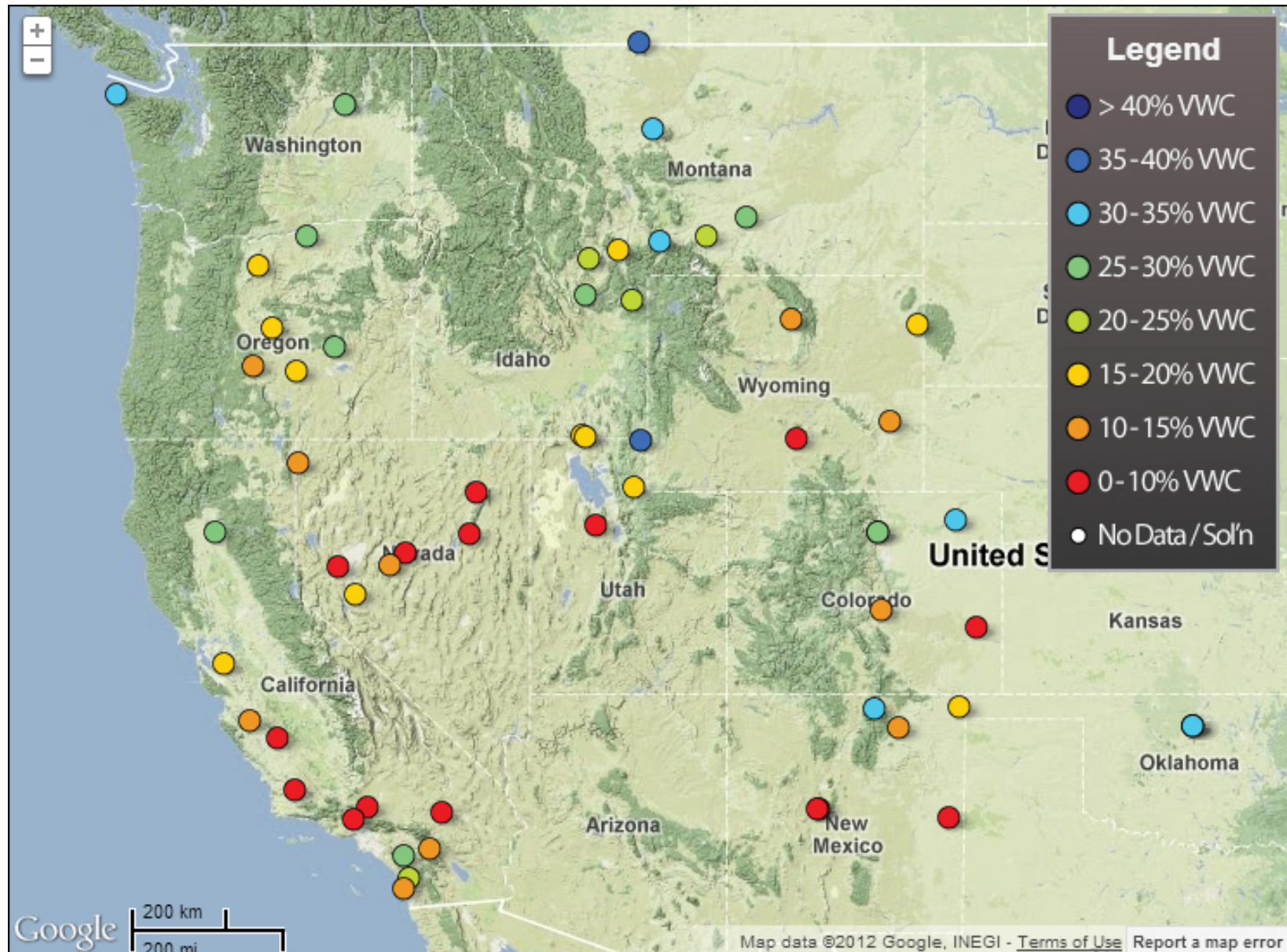
## Next Steps:

- Continued validation, including PBO sites
- Include vegetation effects in algorithm
- variability between ground tracks
- Quantify errors



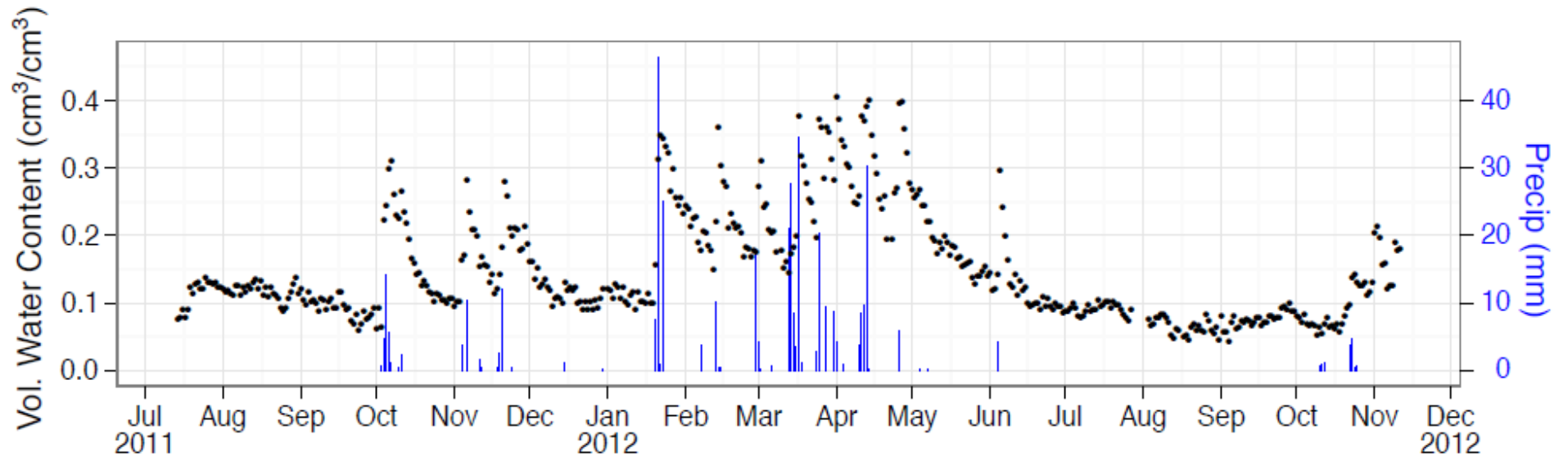
# Current PBO H<sub>2</sub>O soil moisture data

<http://xenon.colorado.edu/portal>



# Example: P226

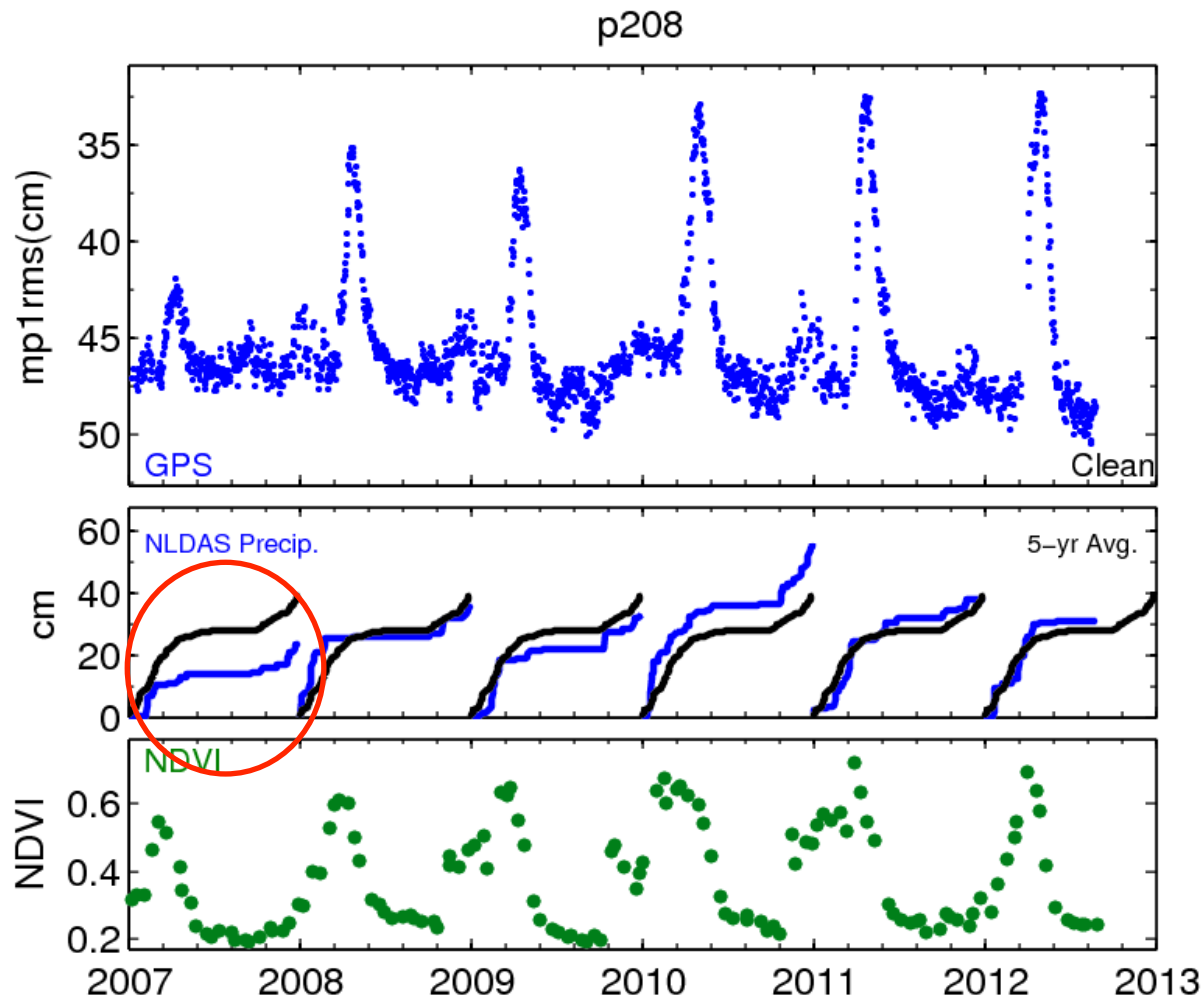
## central California





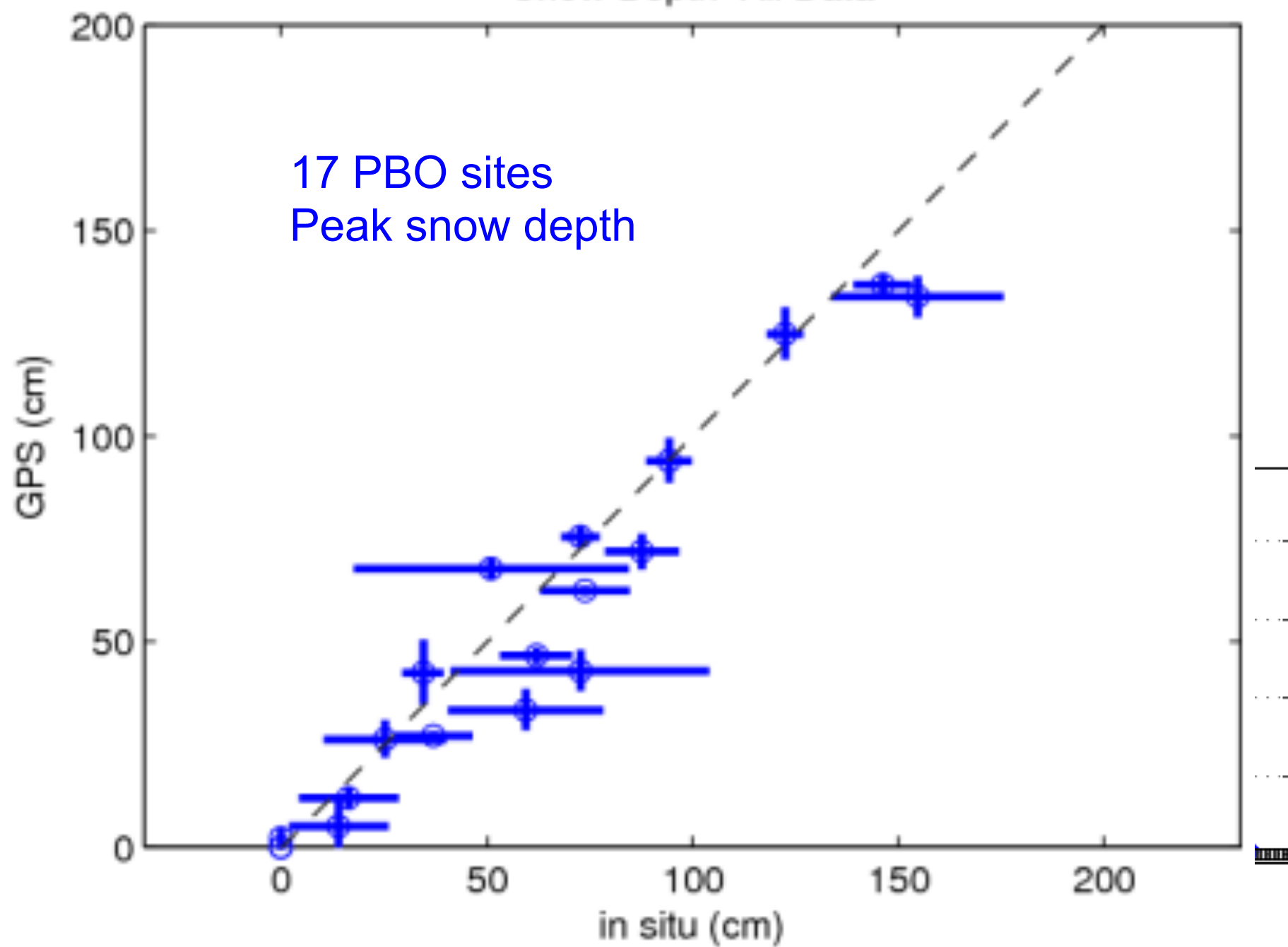
# GPS soil moisture and SMAP

- Soil moisture: intermediate scale, L-band
- Collocated snow depth and vegetation data



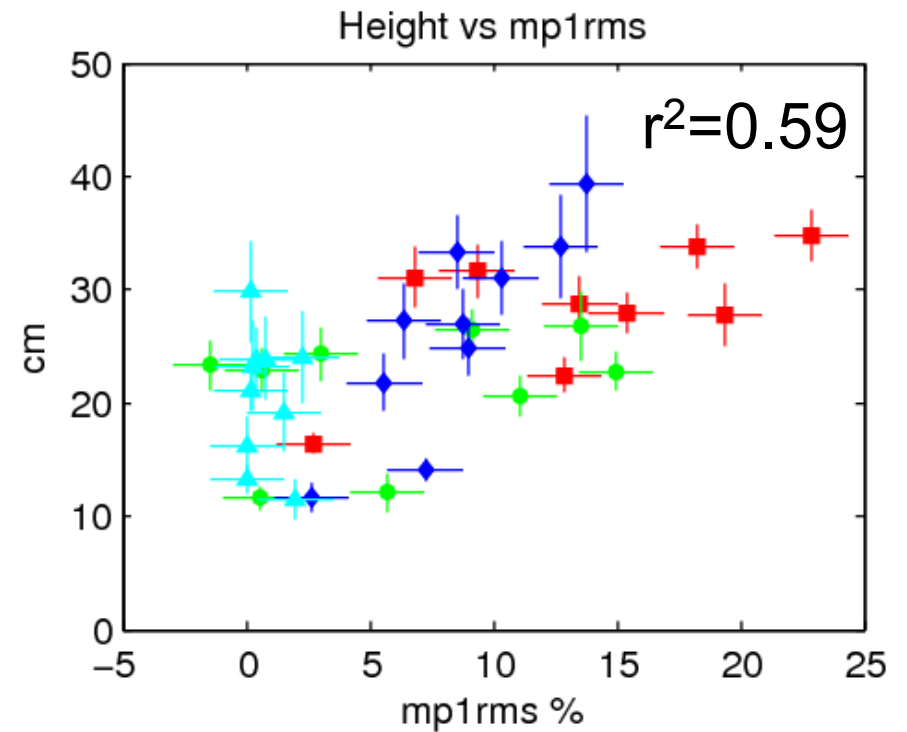
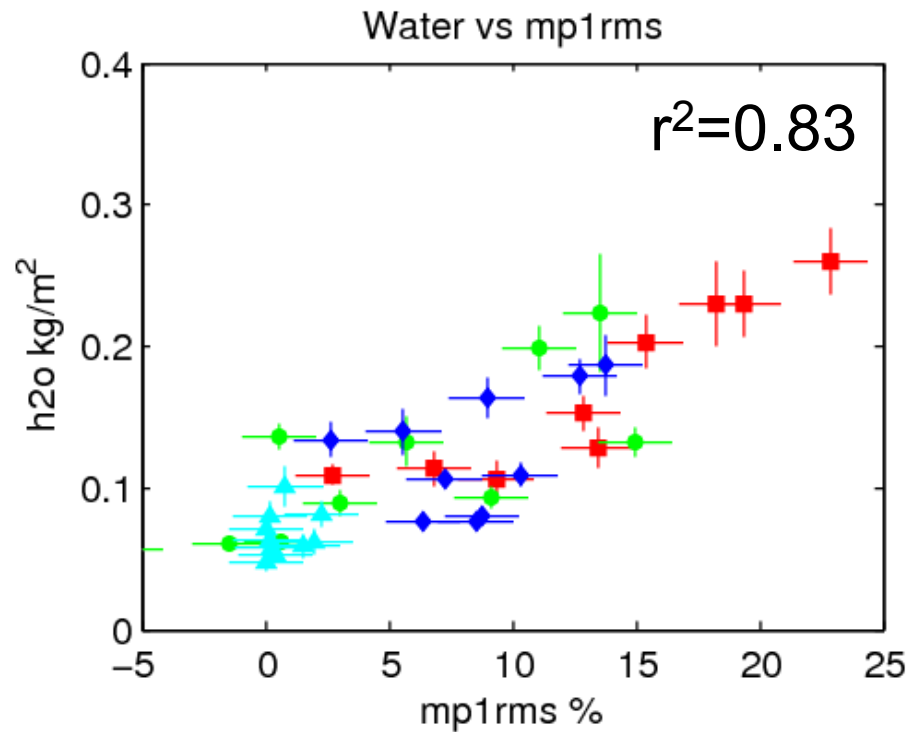


Snow Depth-All Data





# Normalized mp1rms versus field data



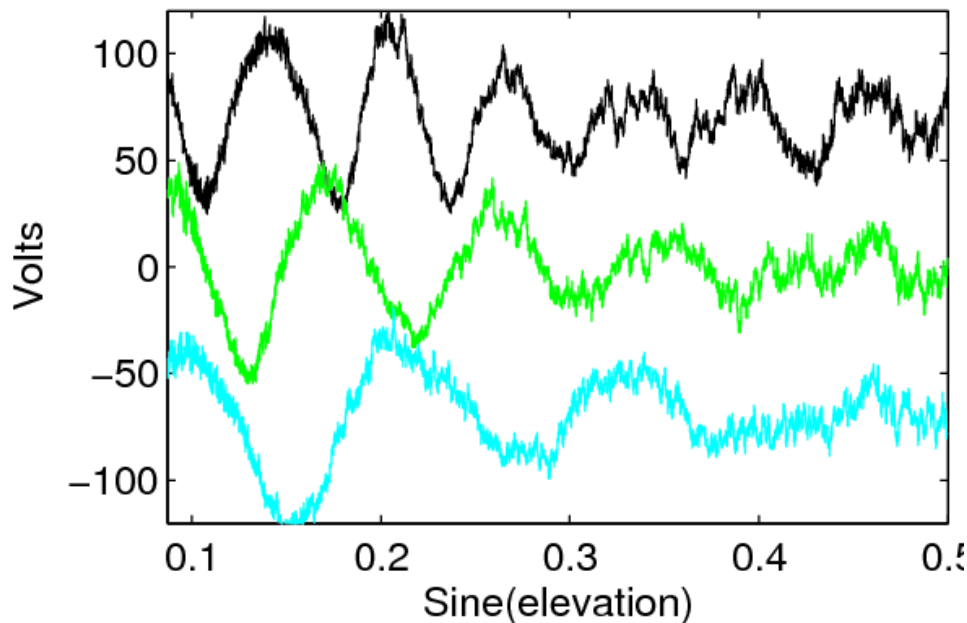
Strong correlation between vegetation water content and mp1rms.

# Snow Depth

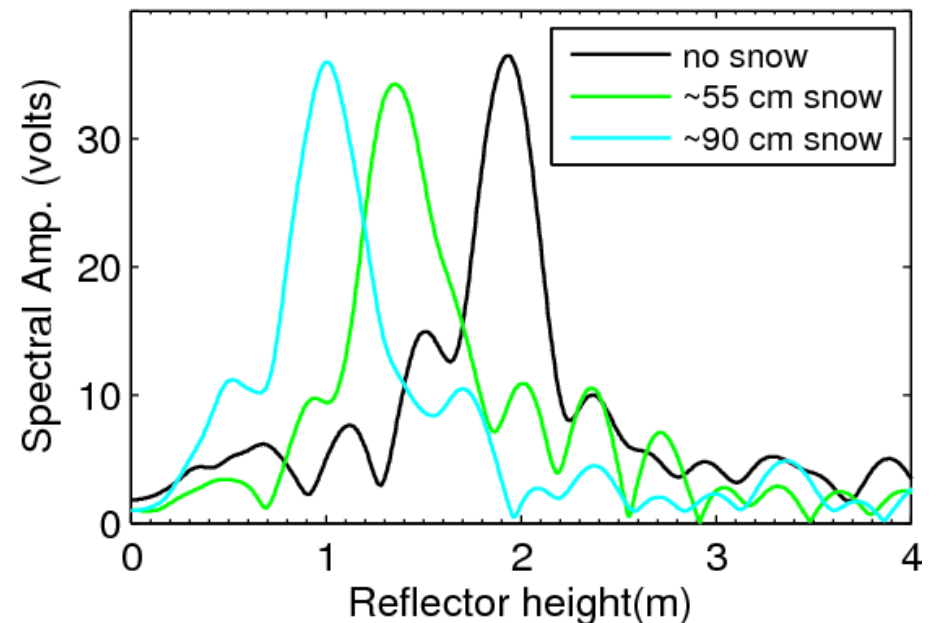
estimate reflector height  
from frequency of interference  
pattern



GPS Reflection Data



Lomb Scargle Periodograms





# snow depth validation

hand measurements

SNOTEL

cameras and poles

ultrasonic range sensors

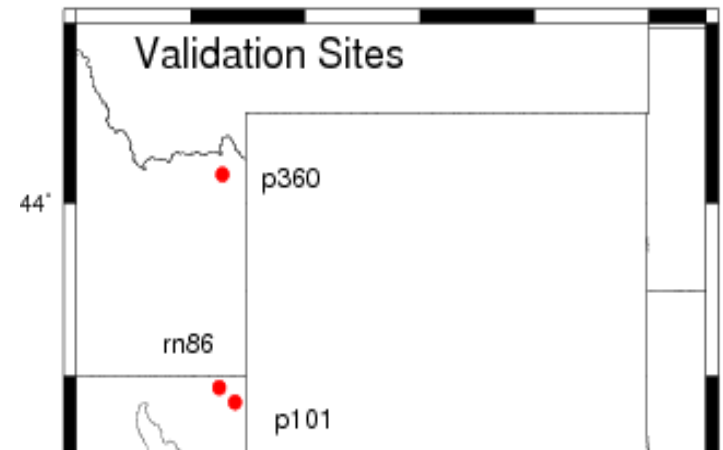
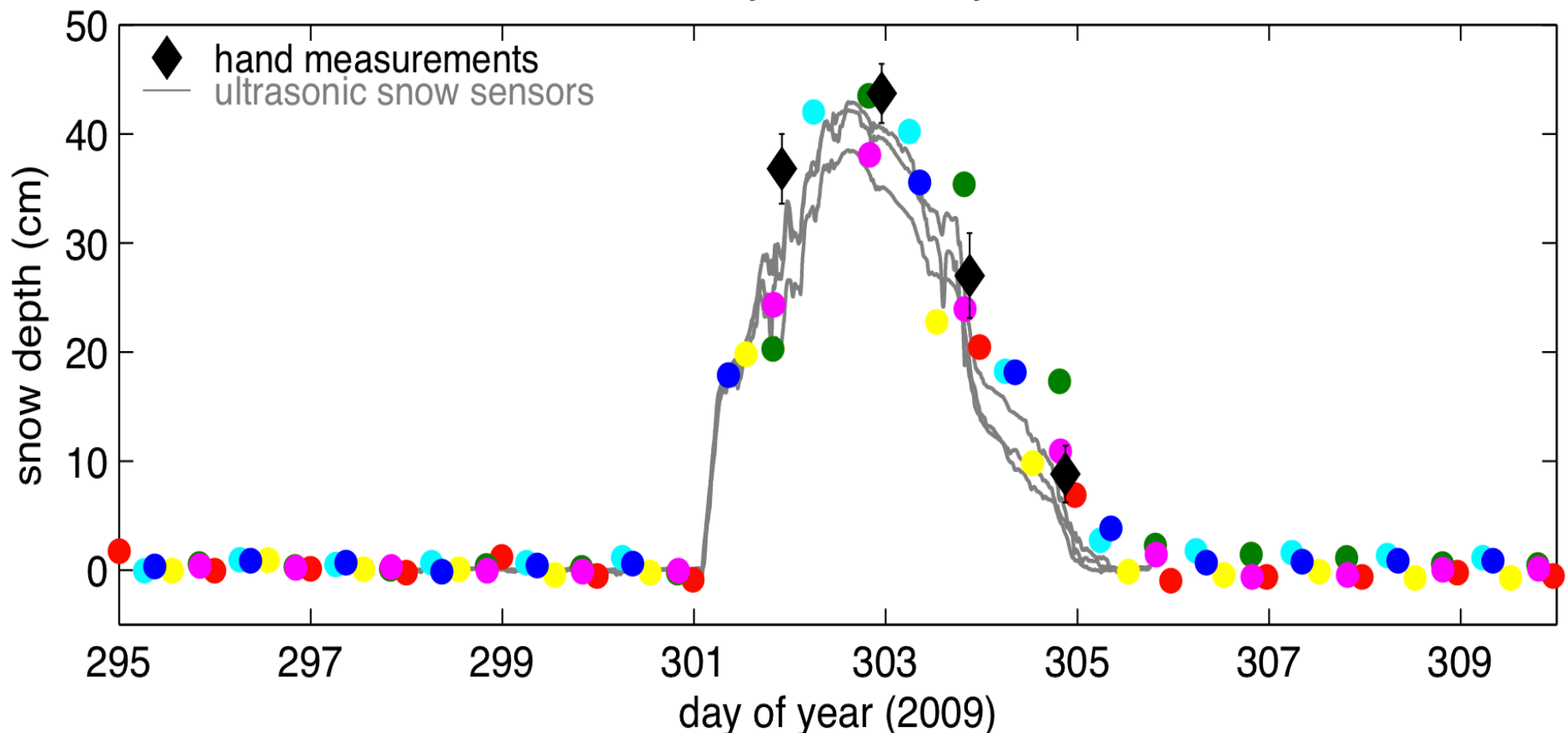


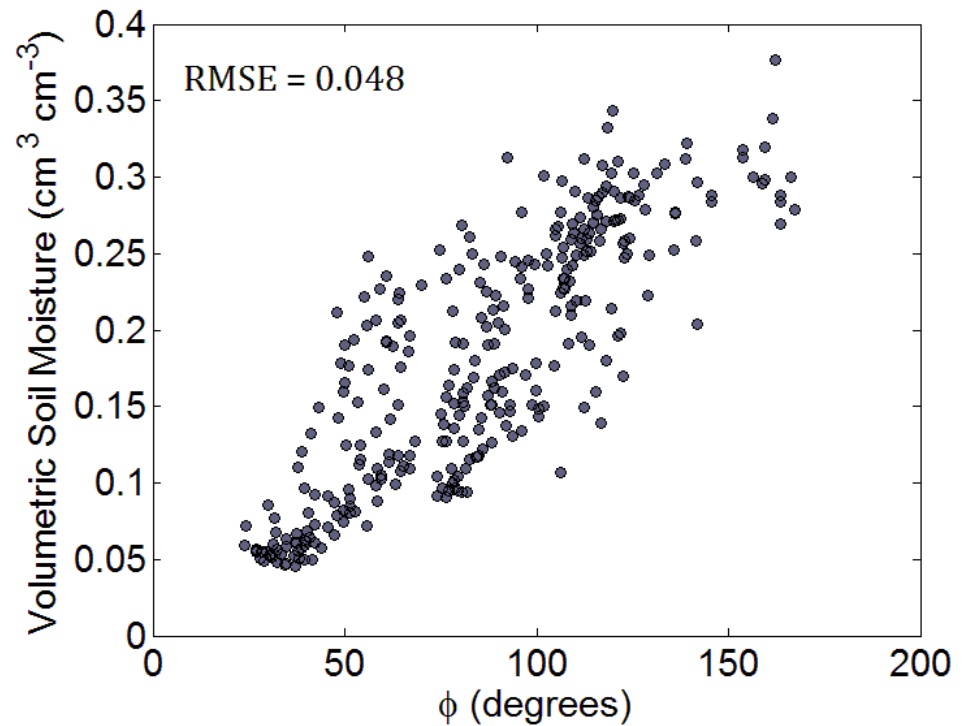
Plate Boundary Observatory Site P041



# Validation:

*In situ* probes

Theta probe surveys



MOISST: 2011

